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### What is "[Embedded - Microcontrollers](#)"?

"[Embedded - Microcontrollers](#)" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

### Applications of "[Embedded - Microcontrollers](#)"

#### Details

|                            |   |
|----------------------------|---|
| Product Status             | Active  |
| Core Processor             | AVR   |
| Core Size                  | 8-Bit   |
| Speed                      | 20MHz   |
| Connectivity               | I <sup>2</sup> C, SPI, UART/USART   |
| Peripherals                | Brown-out Detect/Reset, POR, PWM, WDT   |
| Number of I/O              | 23  |
| Program Memory Size        | 16KB (8K x 16)  |
| Program Memory Type        | FLASH   |
| EEPROM Size                | 512 x 8   |
| RAM Size                   | 1K x 8  |
| Voltage - Supply (Vcc/Vdd) | 1.8V ~ 5.5V   |
| Data Converters            | A/D 8x10b   |
| Oscillator Type            | Internal  |
| Operating Temperature      | -40°C ~ 105°C (TA)  |
| Mounting Type              | Surface Mount   |
| Package / Case             | 32-VFQFN Exposed Pad  |
| Supplier Device Package    | 32-VQFN (5x5)   |
| Purchase URL               | <a href="https://www.e-xfl.com/product-detail/microchip-technology/atmega168pa-mn">https://www.e-xfl.com/product-detail/microchip-technology/atmega168pa-mn</a> |

## 1. Description

The Atmel AVR® core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in a single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega48PA/88PA/168PA provides the following features: 4K/8K/16Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 256/512/512bytes EEPROM, 512/1K/1Kbytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 1 serial programmable USARTs, 1 byte-oriented 2-wire Serial Interface (I2C), a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages), a programmable Watchdog Timer with internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. In Extended Standby mode, both the main oscillator and the asynchronous timer continue to run.

Atmel offers the QTouch® library for embedding capacitive touch buttons, sliders and wheels functionality into AVR microcontrollers. The patented charge-transfer signal acquisition offers robust sensing and includes fully debounced reporting of touch keys and includes Adjacent Key Suppression® (AKS™) technology for unambiguous detection of key events. The easy-to-use QTouch Suite toolchain allows you to explore, develop and debug your own touch applications.

The device is manufactured using Atmel's high density non-volatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The Boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega48PA/88PA/168PA is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega48PA/88PA/168PA is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits.

### 3. Ordering Information

#### 3.1. ATmega48PA

| Speed [MHz] <sup>(3)</sup> | Power Supply [V] | Ordering Code <sup>(2)</sup>  | Package <sup>(1)</sup>   | Operational Range              |
|----------------------------|------------------|---|--|--------------------------------|
| 20                         | 1.8 - 5.5        | ATmega48PA-AU<br>ATmega48PA-AUR <sup>(4)</sup><br>ATmega48PA-CCU<br>ATmega48PA-CCUR <sup>(4)</sup><br>ATmega48PA-MMH <sup>(5)</sup><br>ATmega48PA-MMHR <sup>(4)(5)</sup><br>ATmega48PA-MU<br>ATmega48PA-MUR <sup>(4)</sup><br>ATmega48PA-PU | 32A<br>32A<br>32CC1<br>32CC1<br>28M1<br>28M1<br>32M1-A<br>32M1-A<br>28P3 | Industrial<br>(-40°C to 85°C)  |
|                            |                  | ATmega48PA-AU<br>ATmega48PA-AUR <sup>(4)</sup><br>ATmega48PA-CCU<br>ATmega48PA-CCUR <sup>(4)</sup><br>ATmega48PA-MMH <sup>(5)</sup><br>ATmega48PA-MMHR <sup>(4)(5)</sup><br>ATmega48PA-MU<br>ATmega48PA-MUR <sup>(4)</sup><br>ATmega48PA-PU | 32A<br>32A<br>28M1<br>28M1<br>32M1-A<br>32M1-A<br>28P3                   | Industrial<br>(-40°C to 105°C) |

**Note:**

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Please refer to *Speed Grades* for Speed vs. V<sub>CC</sub>
4. Tape & Reel.
5. NiPdAu Lead Finish.

| Package Type |   |
|--------------|---|
| 28M1         | 28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 28P3         | 28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)  |
| 32M1-A       | 32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 32A          | 32-lead, Thin (1.0mm) Plastic Quad Flat Package (TQFP)  |
| 32CC1        | 32-ball, 4 x 4 x 0.6mm package, ball pitch 0.5mm, Ultra Thin, Fine-Pitch Ball Grill Array (UFBGA) |

## 3.2. ATmega88PA

| Speed [MHz] <sup>(3)</sup> | Power Supply [V] | Ordering Code <sup>(2)</sup>      | Package <sup>(1)</sup> | Operational Range              |
|----------------------------|------------------|-----------------------------------|------------------------|--------------------------------|
| 20                         | 1.8 - 5.5        | ATmega88PA-AU                     | 32A                    | Industrial<br>(-40°C to 85°C)  |
|                            |                  | ATmega88PA-AUR <sup>(4)</sup>     | 32A                    |                                |
|                            |                  | ATmega88PA-CCU                    | 32CC1                  |                                |
|                            |                  | ATmega88PA-CCUR <sup>(4)</sup>    | 32CC1                  |                                |
|                            |                  | ATmega88PA-MMH <sup>(5)</sup>     | 28M1                   |                                |
|                            |                  | ATmega88PA-MMHR <sup>(4)(5)</sup> | 28M1                   |                                |
|                            |                  | ATmega88PA-MU                     | 32M1-A                 |                                |
|                            |                  | ATmega88PA-MUR <sup>(4)</sup>     | 32M1-A                 |                                |
|                            |                  | ATmega88PA-PU                     | 28P3                   |                                |
|                            |                  | ATmega88PA-AN                     | 32A                    | Industrial<br>(-40°C to 105°C) |
|                            |                  | ATmega88PA-ANR <sup>(4)</sup>     | 32A                    |                                |
|                            |                  | ATmega88PA-MMN <sup>(5)</sup>     | 28M1                   |                                |
|                            |                  | ATmega88PA-MMNR <sup>(4)(5)</sup> | 28M1                   |                                |
|                            |                  | ATmega88PA-MN                     | 32M1-A                 |                                |
|                            |                  | ATmega88PA-MNR <sup>(4)</sup>     | 32M1-A                 |                                |
|                            |                  | ATmega88PA-PN                     | 28P3                   |                                |

### Note:

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
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4. Tape & Reel.
5. NiPdAu Lead Finish.

| Package Type |   |
|--------------|---|
| 28M1         | 28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 28P3         | 28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)  |
| 32M1-A       | 32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 32A          | 32-lead, Thin (1.0mm) Plastic Quad Flat Package (TQFP)  |
| 32CC1        | 32-ball, 4 x 4 x 0.6mm package, ball pitch 0.5mm, Ultra Thin, Fine-Pitch Ball Grill Array (UFBGA) |

### 3.3. ATmega168PA

| Speed [MHz] <sup>(3)</sup> | Power Supply [V] | Ordering Code <sup>(2)</sup>       | Package <sup>(1)</sup> | Operational Range              |
|----------------------------|------------------|------------------------------------|------------------------|--------------------------------|
| 20                         | 1.8 - 5.5        | ATmega168PA-AU                     | 32A                    | Industrial<br>(-40°C to 85°C)  |
|                            |                  | ATmega168PA-AUR <sup>(5)</sup>     | 32A                    |                                |
|                            |                  | ATmega168PA-CCU                    | 32CC1                  |                                |
|                            |                  | ATmega168PA-CCUR <sup>(5)</sup>    | 32CC1                  |                                |
|                            |                  | ATmega168PA-MMH <sup>(4)</sup>     | 28M1                   |                                |
|                            |                  | ATmega168PA-MMHR <sup>(4)(5)</sup> | 28M1                   |                                |
|                            |                  | ATmega168PA-MU                     | 32M1-A                 |                                |
|                            |                  | ATmega168PA-MUR <sup>(5)</sup>     | 32M1-A                 |                                |
|                            |                  | ATmega168PA-PU                     | 28P3                   |                                |
|                            |                  | ATmega168PA-AN                     | 32A                    | Industrial<br>(-40°C to 105°C) |
|                            |                  | ATmega168PA-ANR <sup>(5)</sup>     | 32A                    |                                |
|                            |                  | ATmega168PA-MN                     | 32M1-A                 |                                |
|                            |                  | ATmega168PA-MNR <sup>(5)</sup>     | 32M1-A                 |                                |
|                            |                  | ATmega168PA-PN                     | 28P3                   |                                |

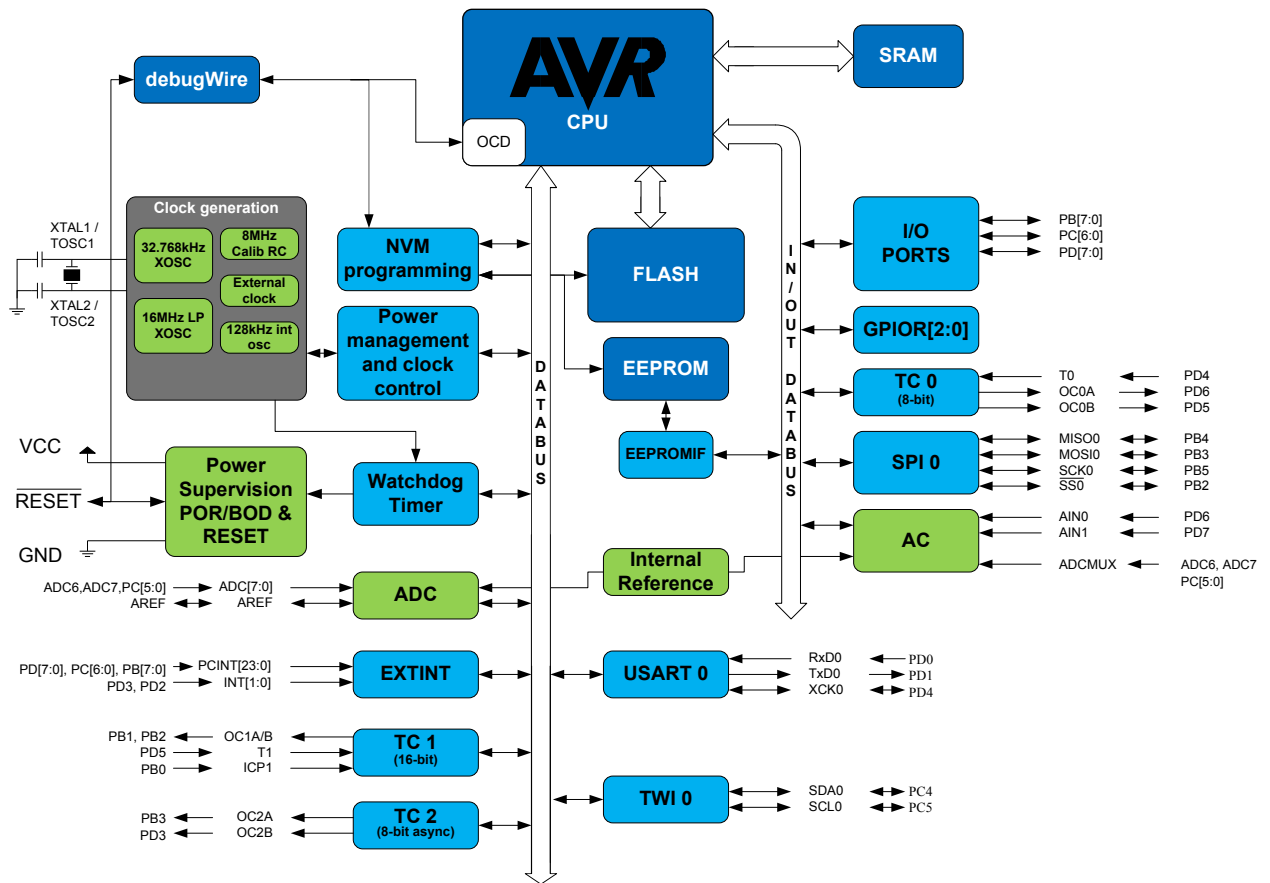
**Note:**

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Please refer to *Speed Grades* for Speed vs.  $V_{CC}$
4. Tape & Reel.
5. NiPdAu Lead Finish.

| Package Type |   |
|--------------|---|
| 28M1         | 28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 28P3         | 28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)  |
| 32M1-A       | 32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 32A          | 32-lead, Thin (1.0mm) Plastic Quad Flat Package (TQFP)  |
| 32CC1        | 32-ball, 4 x 4 x 0.6mm package, ball pitch 0.5mm, Ultra Thin, Fine-Pitch Ball Grill Array (UFBGA) |

## 4. Block Diagram

Figure 4-1. Block Diagram



## 5. Pin Configurations

### 5.1. Pin-out

Figure 5-1. 28-pin PDIP

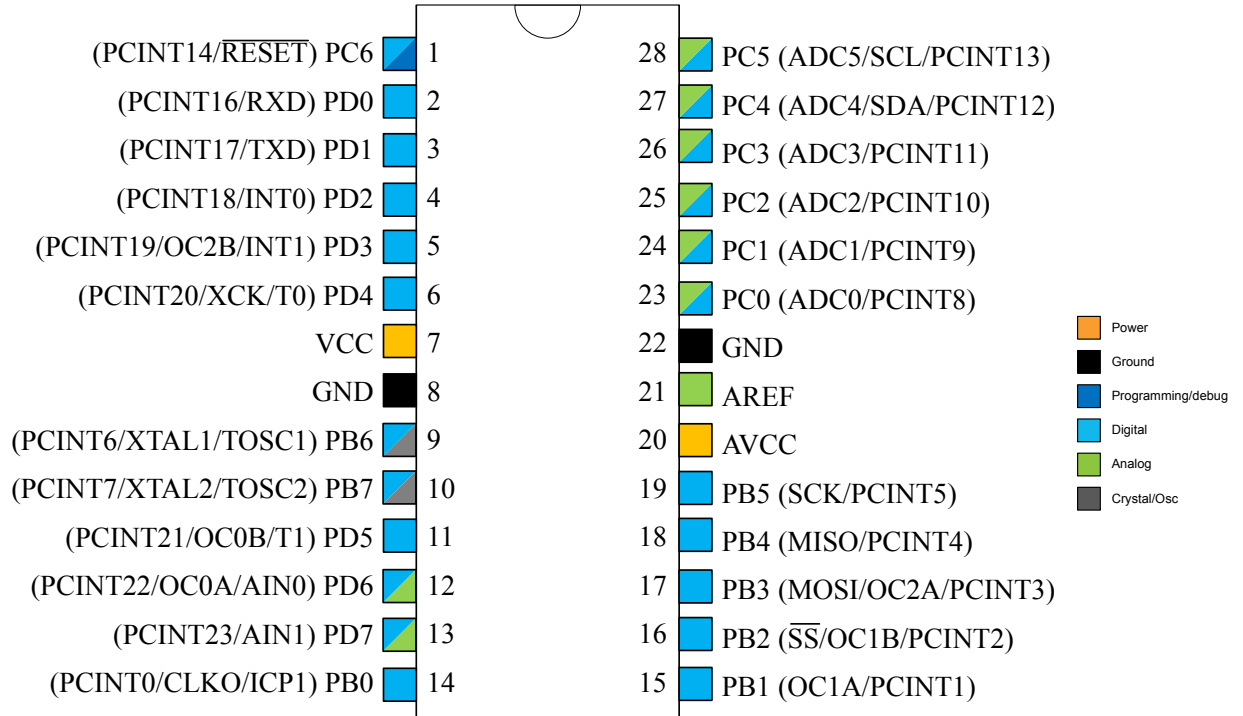
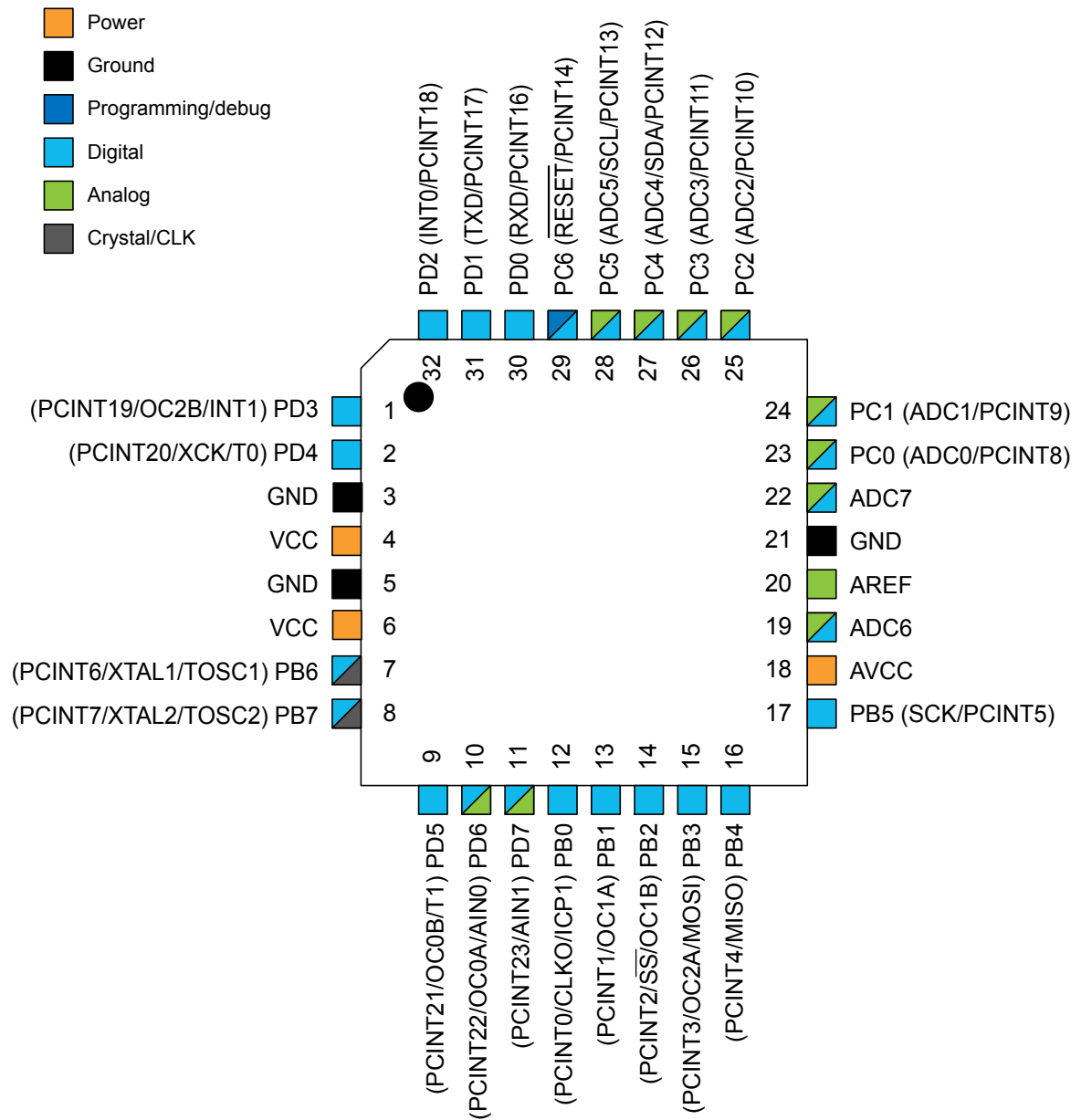


Figure 5-2. 28-pin MLF Top View





**Figure 5-3. 32-pin TQFP Top View**



#### **5.2.9. ADC[7:6] (TQFP and VFQFN Package Only)**

In the TQFP and VFQFN package, ADC[7:6] serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

| (32-pin<br>32UFBGA)<br>Pin# | (32-pin<br>MLF/<br>TQFP)<br>Pin# | (28-pin<br>MLF)<br>Pin# | (28-pin<br>PIPD)<br>Pin# | PAD             | EXTINT | PCINT   | ADC/A<br>C | OSC | T/C #0 | T/C<br>#1 | USART<br>0 | I2C 0 | SPI 0 |
|-----------------------------|----------------------------------|-------------------------|--------------------------|-----------------|--------|---------|------------|-----|--------|-----------|------------|-------|-------|
| A3                          | 29                               | 25                      | 1                        | PC[6]/<br>RESET |        | PCINT14 |            |     |        |           |            |       |       |
| B3                          | 30                               | 26                      | 2                        | PD[0]           |        | PCINT16 |            |     |        |           | RXD0       |       |       |
| A2                          | 31                               | 27                      | 3                        | PD[1]           |        | PCINT17 |            |     |        |           | TXD0       |       |       |
| A1                          | 32                               | 28                      | 4                        | PD[2]           | INT0   | PCINT18 |            |     |        |           |            |       |       |

## 7. Resources

A comprehensive set of development tools, application notes, and datasheets are available for download on <http://www.atmel.com/avr>.

## 8. Data Retention

Reliability Qualification results show that the projected data retention failure rate is much less than 1 PPM over 20 years at 85°C.

## 9. About Code Examples

This documentation contains simple code examples that briefly show how to use various parts of the device. These code examples assume that the part specific header file is included before compilation. Be aware that not all C compiler vendors include bit definitions in the header files and interrupt handling in C is compiler dependent. Confirm with the C compiler documentation for more details.

For I/O Registers located in extended I/O map, “IN”, “OUT”, “SBIS”, “SBIC”, “CBI”, and “SBI” instructions must be replaced with instructions that allow access to extended I/O. Typically “LDS” and “STS” combined with “SBR”, “SBRC”, “SBR”, and “CBR”.

## 10. Capacitive Touch Sensing

### 10.1. QTouch Library

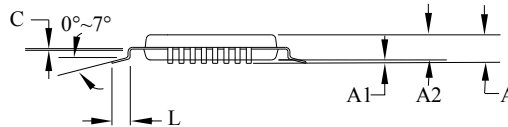
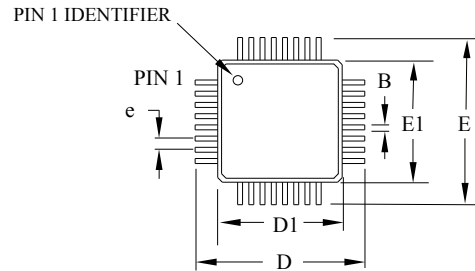
The Atmel® QTouch® Library provides a simple to use solution to realize touch sensitive interfaces on most Atmel AVR® microcontrollers. The QTouch Library includes support for the Atmel QTouch and Atmel QMatrix® acquisition methods.

Touch sensing can be added to any application by linking the appropriate Atmel QTouch Library for the AVR Microcontroller. This is done by using a simple set of APIs to define the touch channels and sensors, and then calling the touch sensing API's to retrieve the channel information and determine the touch sensor states.

The QTouch Library is FREE and downloadable from the Atmel website at the following location: <http://www.atmel.com/technologies/touch/>. For implementation details and other information, refer to the [Atmel QTouch Library User Guide](#) - also available for download from the Atmel website.

## 11. Packaging Information

### 11.1. 32-pin 32A



**COMMON DIMENSIONS**  
(Unit of measure = mm)

| SYMBOL | MIN      | NOM  | MAX  | NOTE   |
|--------|----------|------|------|--------|
| A      | —        | —    | 1.20 |        |
| A1     | 0.05     | —    | 0.15 |        |
| A2     | 0.95     | 1.00 | 1.05 |        |
| D      | 8.75     | 9.00 | 9.25 |        |
| D1     | 6.90     | 7.00 | 7.10 | Note 2 |
| E      | 8.75     | 9.00 | 9.25 |        |
| E1     | 6.90     | 7.00 | 7.10 | Note 2 |
| B      | 0.30     | —    | 0.45 |        |
| C      | 0.09     | —    | 0.20 |        |
| L      | 0.45     | —    | 0.75 |        |
| e      | 0.80 TYP |      |      |        |

**Notes:**

1. This package conforms to JEDEC reference MS-026, Variation ABA.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.10mm maximum.

2010-10-20

**Atmel**

**TITLE**

**32A, 32-lead, 7 x 7mm body size, 1.0mm body thickness,  
0.8mm lead pitch, thin profile plastic quad flat package (TQFP)**

**DRAWING NO.**

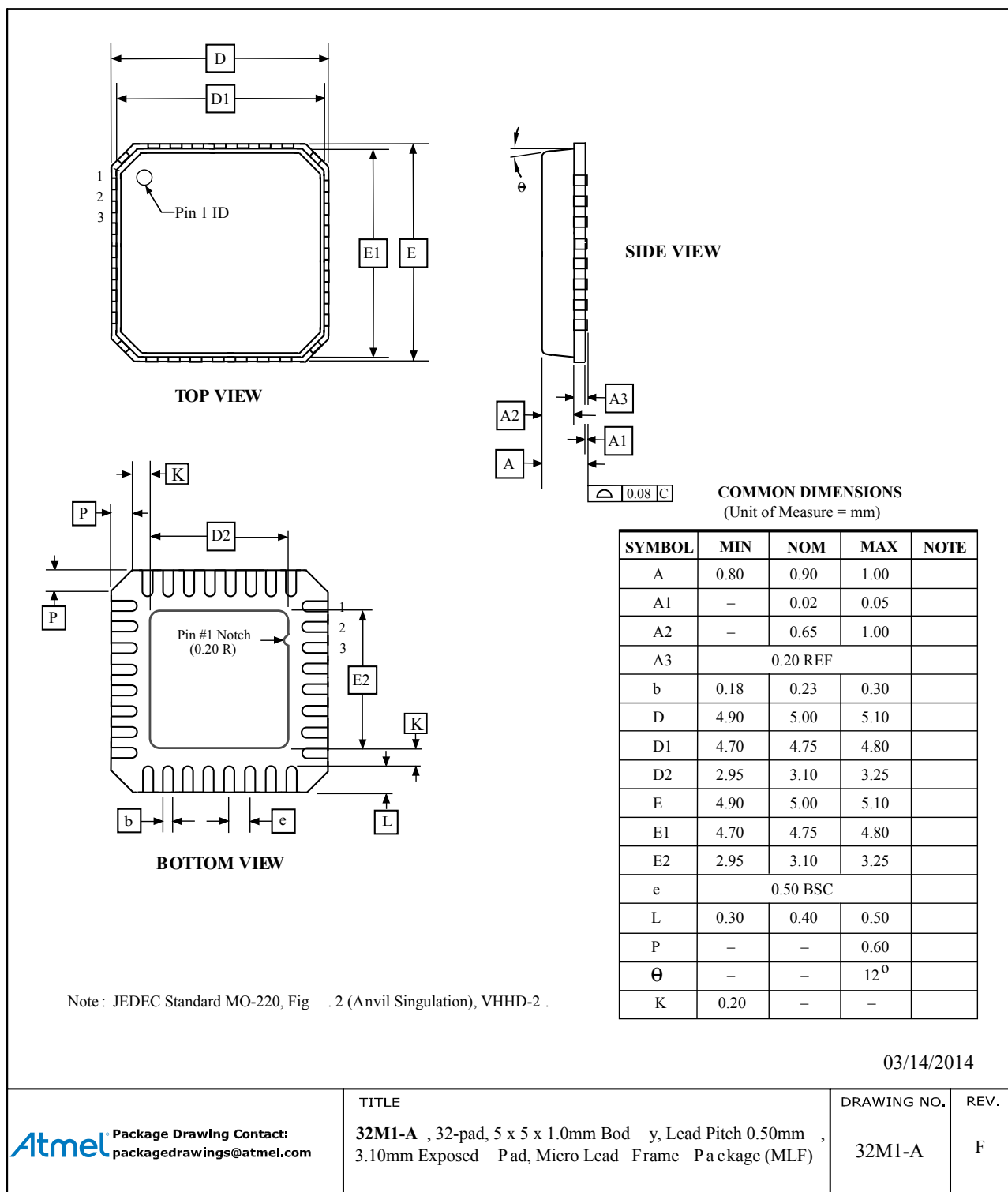
32A

**REV.**

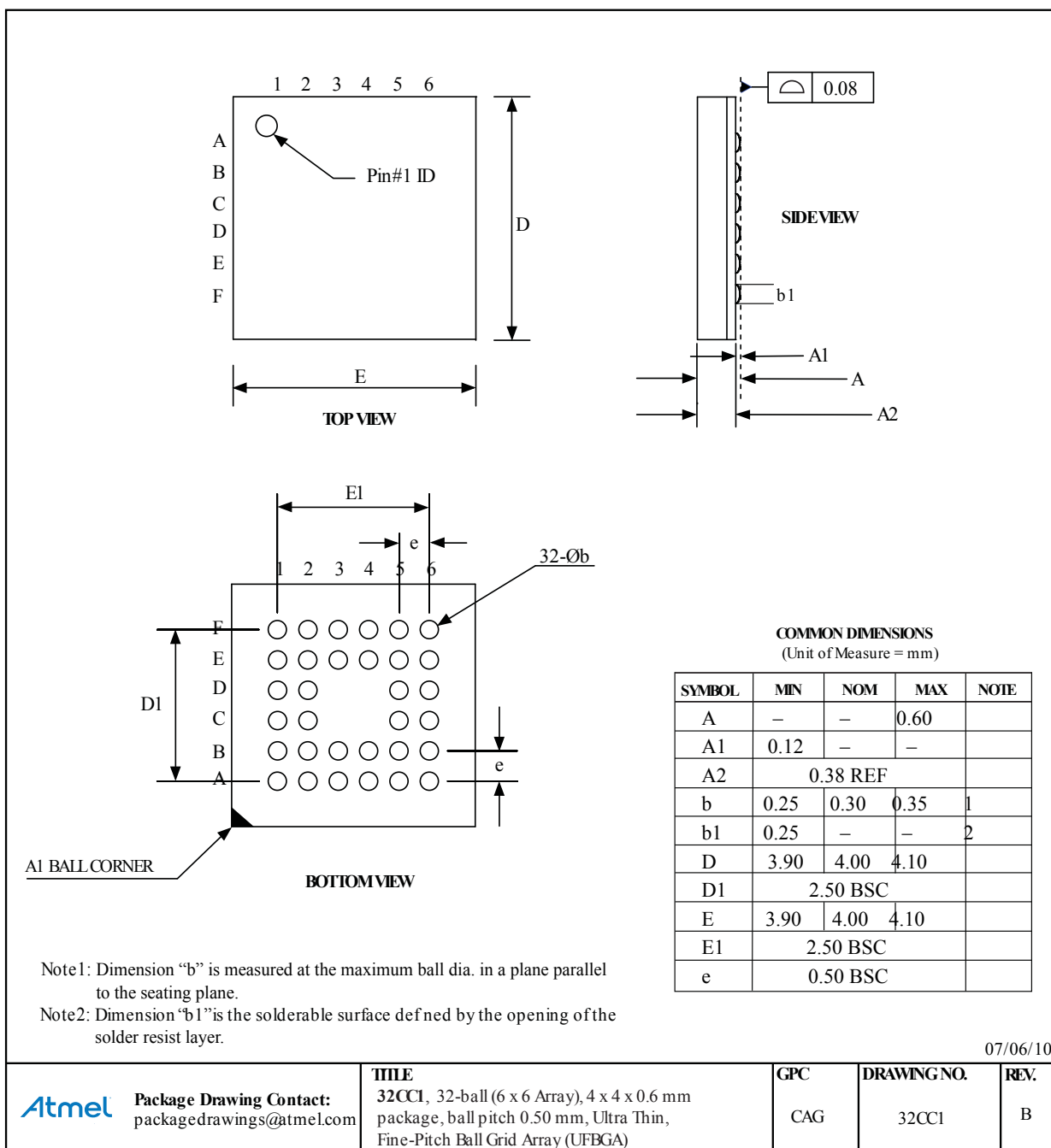
C



## 11.2. 32-pin 32M1-A



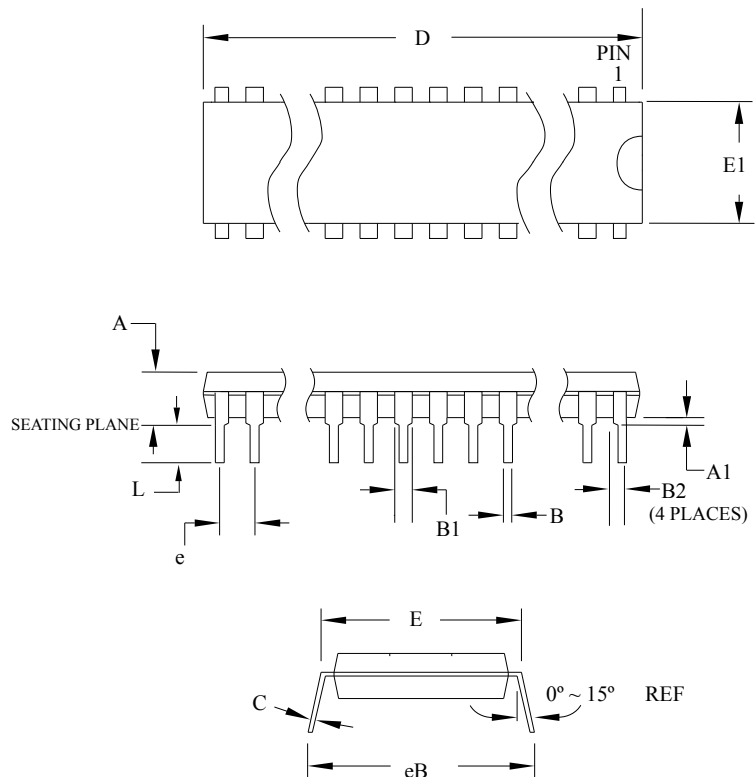
### 11.3. 32-pin 32CC1



## 11.4. 28-pin 28M1



## 11.5. 28-pin 28P3



Note: 1. Dimensions D and E1 do not include mold Flash or Protrusion.  
Mold Flash or Protrusion shall not exceed 0.25mm (0.010").

**COMMON DIMENSIONS**  
(Unit of Measure = mm)

| SYMBOL | MIN       | NOM | MAX    | NOTE   |
|--------|-----------|-----|--------|--------|
| A      | —         | —   | 4.5724 |        |
| A1     | 0.508     | —   | —      |        |
| D      | 34.544    | —   | 34.798 | Note 1 |
| E      | 7.620     | —   | 8.255  |        |
| E1     | 7.112     | —   | 7.493  | Note 1 |
| B      | 0.381     | —   | 0.533  |        |
| B1     | 1.143     | —   | 1.397  |        |
| B2     | 0.762     | —   | 1.143  |        |
| L      | 3.175     | —   | 3.429  |        |
| C      | 0.203     | —   | 0.356  |        |
| eB     | —         | —   | 10.160 |        |
| e      | 2.540 TYP |     |        |        |

09/28/01

Atmel 2325 Orchard Parkway  
San Jose, CA 95131

**TITLE**  
**28P3**, 28-lead (0.300"/7.62mm Wide) Plastic Dual  
Inline Package (PDIP)

**DRAWING NO.**  
28P3

**REV.**  
B

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